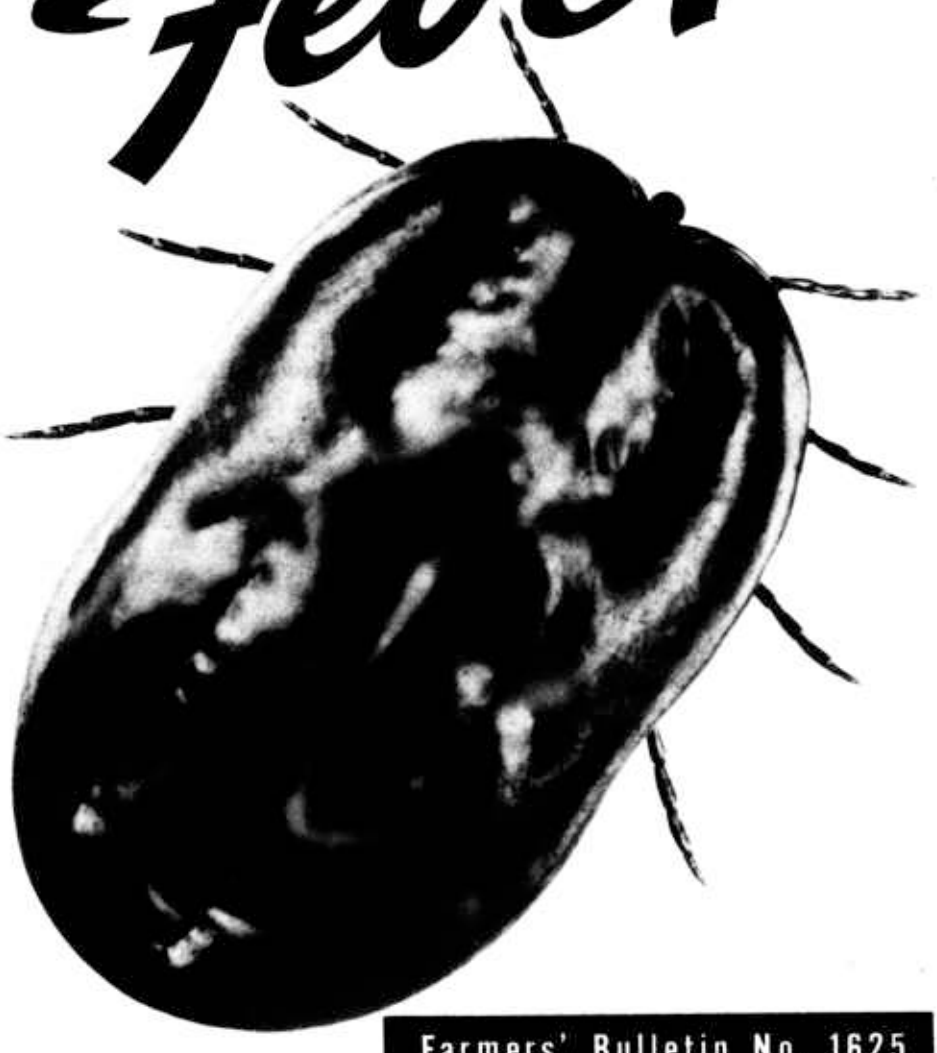
Tick Fever



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THIS PUBLICATION deals with many questions that arise concerning tick fever and the eradication of the cattle tick which transmits this disease. The difference between fever ticks and the harmless ticks often found on cattle and other animals is described and illustrated.

The purpose of the bulletin is to inform livestock owners and the public, especially in the Southern States, regarding the nature of tick fever, the scientific work underlying present methods of eradication, and the benefits to be derived from cooperating with county, State, and Federal authorities in ridding the country of cattle ticks and the disease which they carry.

This bulletin is a revision of and supersedes Farmers' Bulletin 569, entitled "Texas or Tick Fever."

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TICK FEVER

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Contents

INTRODUCTION

Tick fever which, prior to the tick eradication campaign begun in 1906, was a very serious obstacle to the cattle industry of the South, has been fairly thoroughly understood since the investigations made by Smith and Kilborne, of the Bureau of Animal Industry. Their work showed conclusively that the cause of the disease was a minute parasite living within the blood cells, the intermediate stage of the

[1] Retired. This revision was prepared by W. A. MacKellar, in charge of the Interstate Inspection Division.

development of which occurred in the cattle tick, *Boophilus annulatus*,[2] thus making this tick the indirect but absolutely essential factor in the natural production of the disease. Above the latitude where the cattle tick is destroyed by the cold of winter the disease can be controlled by keeping southern tick-infested cattle from passing through the country during certain seasons. It is also known that by severing the relations of the fever tick and native cattle the former may be exterminated, thus making it possible to eradicate the disease, and thereby to remove a constant menace to the southern cattle breeder, feeder, and dairyman. Especial pains will be taken to make as clear as possible the absolutely proved facts regarding the disease so that every cattle owner will be able to recognize the malady and to carry out successfully measures for eliminating the tick which causes it.

NAME AND SYNONYMS

Of the long list of terms applied to this disease, none seem to fill completely all the requirements of an ideal name. Texas fever, although the term most commonly in use in this country, is a very misleading one, as it gives to the uninformed the impression that the disease is confined to the State of Texas. Southern cattle fever is especially inapplicable, as the disease is usually more virulent in northern cattle when once infection becomes manifest than in southern cattle. Probably the best name to apply to the disease, since it can be transmitted only in a natural way by the tick, *Boophilus annulatus*, is that of tick fever. Other synonyms besides those already mentioned are red water, black water, distemper, acclimation fever, murrain, dry murrain, yellow murrain, bloody murrain, Mexican fever, Spanish fever, splenic (or splenetic) fever, protozoan cattle fever, hemaglobinuria, tristeza, paludism of cattle, bovine periodic fever, bovine piroplasmosis, and bovine malaria.

DEFINITION

Tick fever is a specific, infectious disease of the blood of cattle, caused by the development and activity of minute animal parasites (Protozoa) which are conveyed to the affected animals by means of the cattle tick, *Boophilus annulatus*. After the microscopic protozoan is injected into the blood of a susceptible animal it attacks the red blood cells, causing them to break down. The disease is characterized by high fever, by destruction of red corpuscles and the consequent excretion of the coloring matter of the blood by the kidneys causing a reddish discoloration of the urine, by enlarged spleen, engorged liver, thick, flaky bile, more or less jaundice, emaciation, and death in from 10 percent of the chronic to 90 percent of the acute cases. The peculiarity about this disease is that the animals responsible for the spread of the malady are apparently healthy, although containing the Protozoa in their blood, while those that become diseased do not, as a rule, convey the affection to others. In the few instances where they do, it is not by contact, but indirectly by means of the progeny of the ticks from these diseased animals. Infection

[2] The American cattle-fever tick has been given various names, including *Ixodes annulatus* Say, 1821; *I. bovis* Riley, 1869; *Boophilus annulatus* Stiles and Hassall, 1901; and *Margaropus annulatus* Hunter, 1908. The preferred name is the one used here, *Boophilus annulatus*.

is not transmitted by the air, urine, saliva, manure, or in any other natural manner than by cattle ticks.

HISTORY

Tick fever was probably introduced into the United States with the importations of cattle by the Spaniards during the early colonization of Mexico and southern United States.

The disease caused continual losses year after year during the early history of this country. It seems to have been described first by J. Pease toward the close of the eighteenth century. At that time a very severe outbreak of the disease occurred in Lancaster County, Pa., and Pease, after investigating the conditions, claimed it to have been due directly to the shipment of some North Carolina cattle into the State. Experience soon showed that the invariable result following the transportation of southern cattle into the Northern States was the death of all northern cattle along the roads and on the pastures over which the southern cattle had traveled, although the latter animals remained perfectly healthy. In the same way northern cattle taken south almost invariably succumbed to the malady.

These losses prompted the study of the disease by many scientific men, whose investigations soon established the great danger of allowing southern cattle to pass into the Northern States during hot weather, and finally resulted in 1885 in the location of the infected district and the establishment by D. E. Salmon in 1891 of the southern cattle quarantine line.

Smith, of the Bureau of Animal Industry, was the first (1889) to recognize and describe as Protozoa the intracellular parasites which are the direct causative agents of the disease. In 1889 and 1890 Kilborne, of the same bureau, by conclusive field experiments suggested by Salmon, proved the presence of the cattle tick to be essential in the transmission of the disease. This was the first experimental proof furnished on the subject of diseases borne by insects, or diseases that can be carried from one animal to another only by an intermediary host. This mode of transmitting infections has since become familiar to the public by the discovery that certain species of mosquitoes spread malaria and yellow fever to man.

It was suggested by the experiments of the Bureau of Animal Industry in 1892 and 1893 that, through the production of a mild, nonfatal attack of tick fever in northern cattle, a very considerable degree of protection is afforded against the disease when these cattle are subsequently exposed to the infection on tick-infested pastures.

From 1895 to 1897 additional experiments were conducted by the bureau with the object of further demonstrating the possibility of immunizing cattle against tick fever by the use of blood obtained from southern cattle; and experiments with a similar object in view were likewise instigated and perfected about this time at the experiment stations of Missouri, Texas, Mississippi, Louisiana, and by the Australian Government, with most excellent results. Later experiments with the disease have been performed principally with the view to obtaining a satisfactory chemical solution in which to dip tick-infested cattle (fig. 1) for the purposes of destroying these parasites, and of developing some methods that may be easily carried out for freeing fields, farms, and counties of the cattle tick.

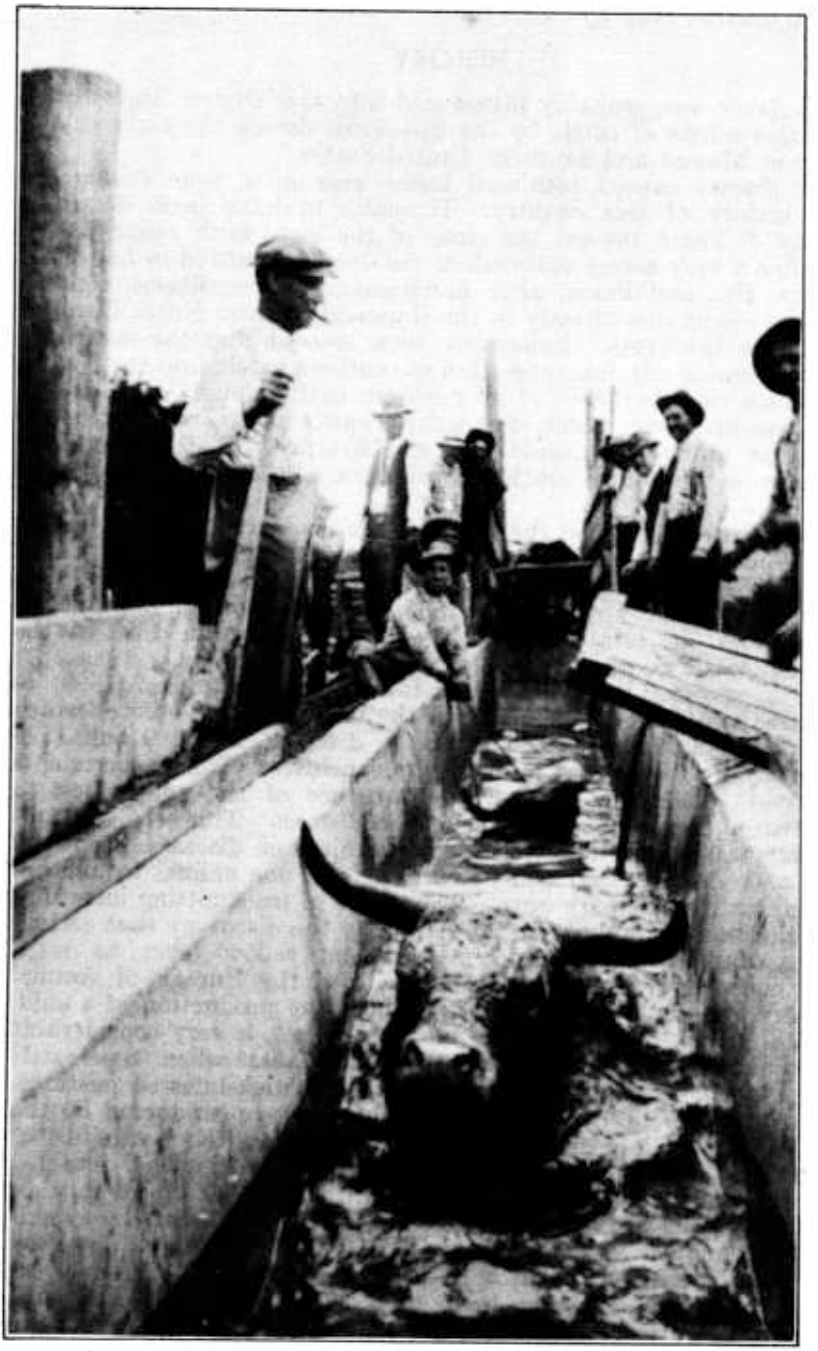

FIGURE 1.—Dipping cattle to eradicate ticks. The dipping vat contains a weak arsenical solution, harmless to cattle but fatal to ticks

The results obtained in these experiments were so promising that it was believed to be feasible to undertake the complete eradication of the fever tick from the United States, and on July 1, 1906, Congress made available an appropriation of $82,500 with which to begin this work. Since that time this project has continued without interruption. The United States has been nearly freed from this parasite, thereby eliminating losses from the disease.

CAUSE OF THE DISEASE

The primary or direct cause of tick fever is the microparasite *Piroplasma bigeminum*, belonging to the lowest form of animal life, the Protozoa. This minute parasite is found in the blood (fig. 2, No. 5) in every case of tick fever; and by inoculating blood containing it into susceptible cattle, the disease can be invariably transmitted, thus proving its direct causative effect in the production of the malady. After entering into the circulation the Protozoa undergo several stages of development which will not be dwelt on here. The parasites may occupy nearly one-fourth of the body of the red blood cells and, as can be readily understood, exert a detrimental influence upon them. The periphery of these blood cells becomes shriveled or crumpled, and they finally break up, liberating the Piroplasma, which may be observed as free bodies in the circulation—most frequently in the kidneys. The stage of reproduction or multiplication of these Protozoa has never been observed in this laboratory, but that it does occur is proved by the fact that inoculation of a small quantity of virulent blood into susceptible animals will give rise to the disease with myriads of parasites in the blood. The natural path of entrance of these Protozoa, however, is by one channel only, namely, through the bite of the cattle tick. Therefore a knowledge of the habits and life history of the latter is extremely important in controlling the disease, because without this tick the fever would be unknown.

LIFE HISTORY OF THE CATTLE TICK AND THE PART PLAYED BY IT IN PRODUCING TICK FEVER

In telling the interesting and important life history of this tick, it is well to start at the point where the fully developed and fertilized female, being engorged with blood and ready to lay her eggs, loosens her hold on the bovine animal and drops to the ground. On reaching the ground she may lie quietly for several days before depositing her eggs. Egg laying may consume from 4 to 8 days in summer and 2 weeks or even longer in the fall. The number of eggs laid by a fully developed female varies from 1,500 to 3,000, while the immature females also lay eggs, but in much smaller numbers. After laying is finished the female is small and shriveled up and, having fulfilled her mission, soon dies (fig. 2, No. 3). The eggs, which are light brown and waxy in appearance, proceed to develop the larvae, or seed ticks, the time required for which varies from 13 days to 6 weeks, depending on the conditions of temperature, moisture, soil, etc. These eggs, however, are very tenacious of life, and under unfavorable conditions may remain dormant for several months—from late fall to early spring.

The larvae, or seed ticks, are minute, six-legged parasites of a brownish, waxy color, and about one thirty-second of an inch in size (fig. 2, No. 2). They crawl actively about on the ground and among

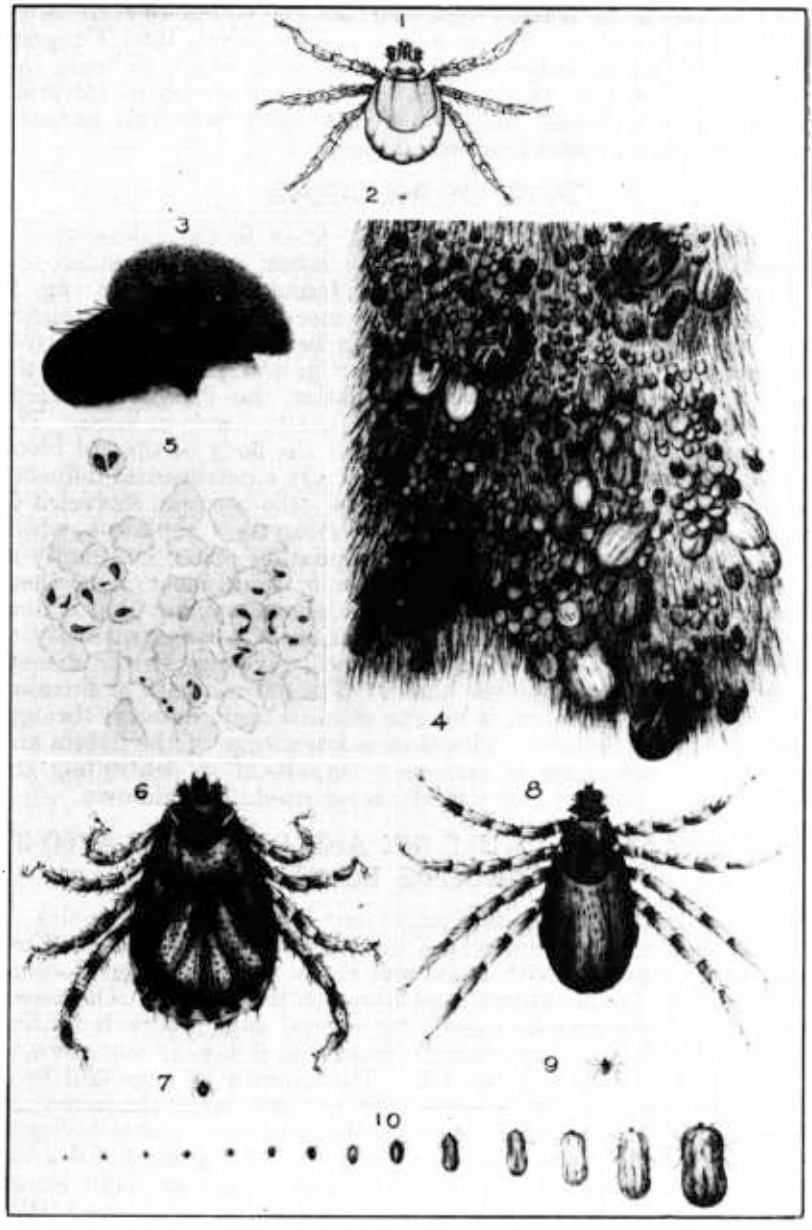

FIGURE 2.—Tick-fever Protozoa and the ticks which transmit them: 1, Larva of cattle tick (× 25); 2, same (natural size); 3, mature female and eggs; 4, hide showing cattle ticks; 5, blood cells containing tick-fever Protozoa (× 1,000); 6, male cattle tick (× 15); 7, same (natural size); 8, young female cattle tick (× 15); 9, same (natural size); 10, various stages of cattle ticks

leaves, bunching in large numbers on grass blades, shrubs, weeds, and fence posts, to await an opportunity for attachment to their passing host. The parasitism is so perfect that in case no cattle or horses are present no further development occurs, and death finally results. It is known, however, that these larval forms can live for 3 or 4 months on the ground in warm weather independent of their host, and from late September until April during an open winter. When they find cattle, however, they fasten themselves to the soft skin inside the thighs and flanks, on the escutcheon, along the belly and brisket, around the root of the tail, and inside the forelegs (fig. 2, No. 4). They obtain their nourishment by drawing blood from the host, and can convey the fever at this stage, although so small as scarcely to be detected by the naked eye. After being on the animal about 1 week the seed tick casts its covering (molts) and appears as the eight-legged, nymph stage of the parasite, having added one pair of legs posteriorly. During the nymphal stage the sexual organs develop, and at the second molting, from the nymphal to the adult stage, the sexual organs are complete. The male and female at this stage are about the same size, as the female does not become very large until after she becomes fertilized, which occurs about 2 weeks after the six-legged seed tick reaches its host, or shortly after the second molting (fig. 2, Nos. 7 and 9). After mating, the female slowly enlarges for 6 to 20 days in summer, and then rapidly increases in size in the course of a day or two before dropping from the animal. In fall and winter, development occurs more slowly, the tick not falling off for 6 weeks or more. After reaching the ground the female soon commences to deposit eggs, thus completing the life cycle, which requires from 6 to 10 weeks in warm weather, or a much longer period during the cold season.

It will thus be seen that these females transmit the infection through their eggs to their progeny, and the latter have the power to infect any susceptible animal to which they attach. The disease, therefore, is not conveyed by the same ticks which take up the infected blood, but only through the generation descending from them.

Although young ticks are very active, neither they nor the adult ticks are capable of crawling very far, but they may be transported long distances by animals, cattle cars, trucks, and hides, to reinfest free areas.

HOW TO DISTINGUISH HARMLESS TICKS FOUND ON CATTLE FROM CATTLE-FEVER TICKS

The fever tick is continually confused with a number of other ticks occasionally found on cattle, which, so far as concerns the transmission of tick fever, are entirely harmless to them. It is this lack of identification and the inability of many cattle owners to distinguish between these various ticks that have caused so many diverse opinions regarding the important part played by the cattle tick in transmitting tick fever. In order to differentiate between the ticks that may be found on cattle, a brief description of the upper surface of the maturing or adult female of each is here given, together with illustrations of this view of the ticks, natural size, and also magnified four diameters. It is not thought necessary to describe the male

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and immature female ticks at this time, inasmuch as these ticks are much smaller in size, and therefore it is more difficult to recognize them by means of the naked eye. Moreover it is usually possible to secure a maturing female in those instances where a diagnosis is desired, and at this stage of development ticks possess certain characteristic features or markings which should cause them to be classified readily as harmful or harmless even by superficial examination.

There are eight species of ticks which have been found on cattle in this country, but the first six mentioned are by far the most common. They all show the same successive stages of development, namely, eggs, larvae or seed ticks, nymphs, and adult male and female ticks. Those parts of the adult female tick which will be described below are the head and adjacent shield—which together have erroneously been termed the head parts—and the back of the body, since these portions of the parasite furnish features which to the naked eye are the most readily distinguished by cattle owners. Much stress cannot be laid upon the color of these various ticks, as it changes considerably with age.

CATTLE TICK

Figure 3, 1a, shows the natural size of an adult female cattle tick (*Boophilus annulatus*), whose characteristic markings are better brought out in No. 1, magnified four times. This tick may be readily distinguished from the other seven ticks by the small size and the color of the head and shield, the so-called head parts, whose lateral borders are straighter and more nearly parallel, as shown in No. 1b. These head parts are short and relatively broad and dark reddish brown or chestnut brown in color. The body is oblong oval in shape and may reach one-half inch in length. The color varies from a dull yellow to an olive brown; often it is mottled with irregular areas of yellow and brown or streaked with wavy lines of these colors. Two grooves or indentations are seen running from the front to the rear on the skin of the back, which become almost, if not entirely, effaced at about the middle of the body. Another groove is seen between these two grooves in the posterior half of the body. These grooves are caused by the contraction of the muscles of the body and therefore vary considerably, entirely disappearing when the tick is full of blood. They are very distinct when the ticks have been removed from cattle several days. The four pairs of legs are brown, moderately long, and very slender. This tick is found principally on cattle, less frequently on horses, mules, and asses, and occasionally on deer.

TROPICAL CATTLE TICK

The tropical cattle tick, *Boophilus microplus*, is regarded by some authorities as only a variety of the common cattle tick, *Boophilus annulatus*. The females of these two ticks are, according to most authorities indistinguishable. The males, however, are easily separated by the presence in the tropical cattle tick of a spinelike caudal process, located on the posterior margin of the body.

The hosts reported for the tropical cattle tick include, besides cattle, deer, horses, and goats; the dog and man have occasionally been reported as hosts of this tick. Formerly, the distribution of this tick in the United States was confined to the peninsula of Florida and to

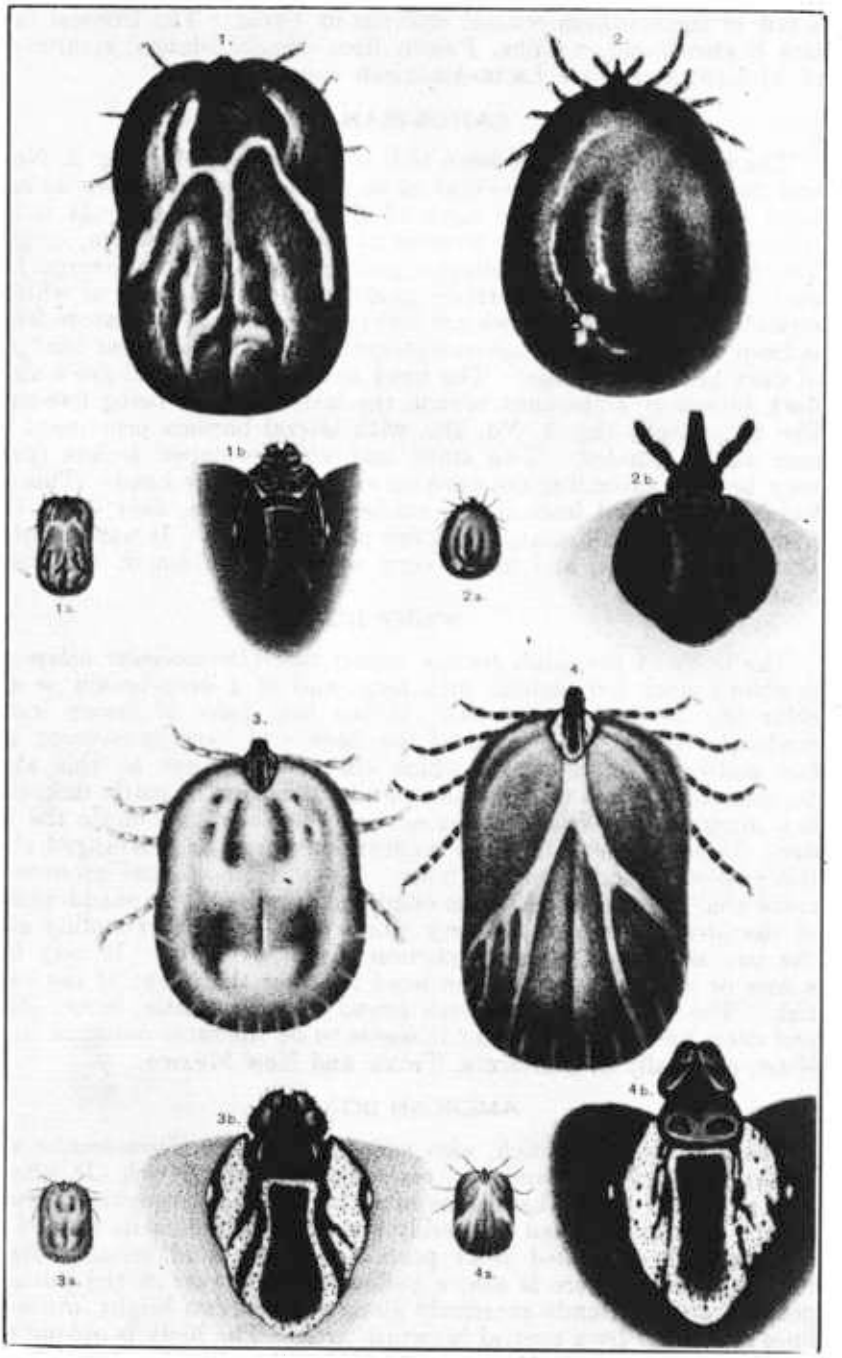

FIGURE 3.—Various ticks that infest cattle. 1. Mature female cattle tick, enlarged; 1*a*, same, natural size; 1*b*, head and shield of same, magnified 15 times. 2. Mature female castor-bean tick, enlarged; 2*a*, same, natural size; 2*b*, head and shield of same, magnified 15 times. 3. Mature female winter tick, enlarged; 3*a*, same, natural size; 3*b*, head and shield of same, magnified 15 times. 4. Mature female dog or wood tick, enlarged; 4*a*, same, natural size; 4*b*, head and shield of same, magnified 15 times. See also Figure 4

a few of the southern coastal counties of Texas. The tropical cattle tick is also found in Cuba. Puerto Rico, Virgin Islands, greater part of Mexico, and other Latin-American countries.

CASTOR-BEAN TICK

The body of the castor-bean tick (*Ixodes scapularis*) (fig. 3, Nos. 2 and 2a) resembles in shape that of an eggplant, and it takes its name from its similarity to the bean of the castor-oil plant. It is lead colored, with a variegated mixture of yellowish red, brown, or gray. The body contains two anterior grooves that slightly diverge from each other, and three posterior grooves, the middle one of which is straight, while the other two are curved outward. The mature female is from three-eighths to seven-sixteenths inch long and has four pairs of dark-brown, thin legs. The head and adjacent shield are a shiny, dark brown or a chestnut brown, the latter portion being five-sided, like a pentagon (fig. 3, No. 2b), with lateral borders prominent and rear angle rounded. Two stout and well-developed feelers (palpi) may be seen extending outward on each side of the head. This tick has been collected from sheep, cattle, goats, horses, deer, dogs, cats, foxes, rabbits, birds, man, and a few other animals. It was one of the first ticks studied, and has a very wide distribution in the United States.

WINTER TICK

The body of the adult female winter tick (*Dermacentor albipictus*) is oblong oval, five-eighths inch long, and of a deep-brown or slate color (fig. 3, Nos. 3 and 3a). It has four pairs of brown legs of moderate length. The skin of the back and head is covered with fine points, or punctations, which almost disappear at this stage. Besides the grooves that are located like those in the cattle tick, there is a marginal groove extending around the body just inside the border. There are also 11 small indentations (festoons) arranged about the posterior margin of the body. These festoons and grooves become shallow or effaced in the engorged female. The shield portion of the head parts has a silvery white metallic rust extending along the two sides and posterior portion (fig. 3, No. 3b). It may have a rose or greenish tinge. The head is larger than that of the cattle tick. The winter tick has been found on man, cattle, horse, sheep, and deer; and in this country it seems to be the most common in the West, especially in California, Texas, and New Mexico.

AMERICAN DOG TICK

The American dog tick, also called wood tick (*Dermacentor variabilis*) (fig. 3, Nos. 4 and 4a), resembles the winter tick (*D. albipictus*) so closely that a hand lens must be used to distinguish between them. However, it can be readily known from the cattle tick by the fact that the so-called head parts are longer and broader (fig. 3, No. 4b). Here there is also a yellowish-white rust in the posterior portion which extends anteriorly along each as two bright, iridescent lines separated by a central brownish area. The body is oblong oval in shape and measures as much as three-fifths inch in length. The skin of the back contains grooves like those found in cattle ticks, and, in addition, another groove extending around just inside the margin together with 11 smaller grooves (festoons) of the posterior

border. These lines, so distinct in the young female, become shallow at maturity. This tick has been found on man, cattle, dogs, horses, rabbits, and panthers, and has been collected in woods and on uncultivated lands in many sections of this country, especially in eastern United States.

LONE STAR TICK

As indicated by Nos. 1 and 1a of figure 4, the body of the lone star tick (*Amblyomma americanum*) is oblong oval and of a yellowish-gray or brown color. The skin is rough and puckered unless the body is full of blood. The reddish-brown area at the front of the tick is composed of the head and head shield. The latter extends backward a short distance to form a triangle, in the apex of which is a white or metallic-yellow spot, from which it derives its name "lone star" (fig. 4, No. 1b). The mature female may reach one-half inch in length and has four pairs of long thin legs. This tick has been found on cattle, dogs, horses, sheep, goats, hogs, and man, and is very widely distributed in the United States.

EAR TICK

As will be observed in Nos. 2 and 2a of figure 4, the shape of the ear tick (*Otobius mégnini*) is similar to that of the body of a violin. It is nearly twice as long as broad, rounded at both ends, narrower behind than in front, and slightly constricted in the middle. In color it varies from gray or brown to violet, and has two grooves behind the head, with a middle one in the posterior portion. On the skin of the back are numerous minute spines or stiff hairs. The adult females are from one-fourth to three-eighths inch in length, and have four pairs of long, stout legs. The anterior portion of the tick is curved downward to form a cover for the very small and short head, which can be seen only from the under side of the tick. The feelers (palpi) and beak, however, stick out from under the front part of the body and can be seen from above (fig. 4, No. 2b). This tick is found in the ears of cattle, horses, mules, asses, and other animals in the South and West.

CHICKEN TICK

In shape and appearance the chicken tick (*Argas miniatus*) is like an enlarged bedbug, and is of a uniform, reddish-brown color, with four pairs of lighter-colored legs. The skin is wrinkled and contains very short and minute hairs. On the top as well as the bottom of the tick are numerous bright pits or cavities with raised borders (fig. 4, Nos. 3 and 3a). These vary in size, are arranged in rows radiating from the center, more or less uniformly, and are usually symmetrical on each side. It is about three-eighths inch in size when mature. The head is so completely covered by the body that it cannot be seen from the back (fig. 4, No. 3b). This tick has been observed on cattle once only but is frequently found on chickens, turkeys, and other birds in the South.

EUROPEAN DOG TICK

The body of the European dog tick (*Ixodes hexagonus*) is oval in shape and of an ashy color (fig. 4, Nos. 4 and 4a). The grooves on the back are united in an arch in front and diverge in the pos-

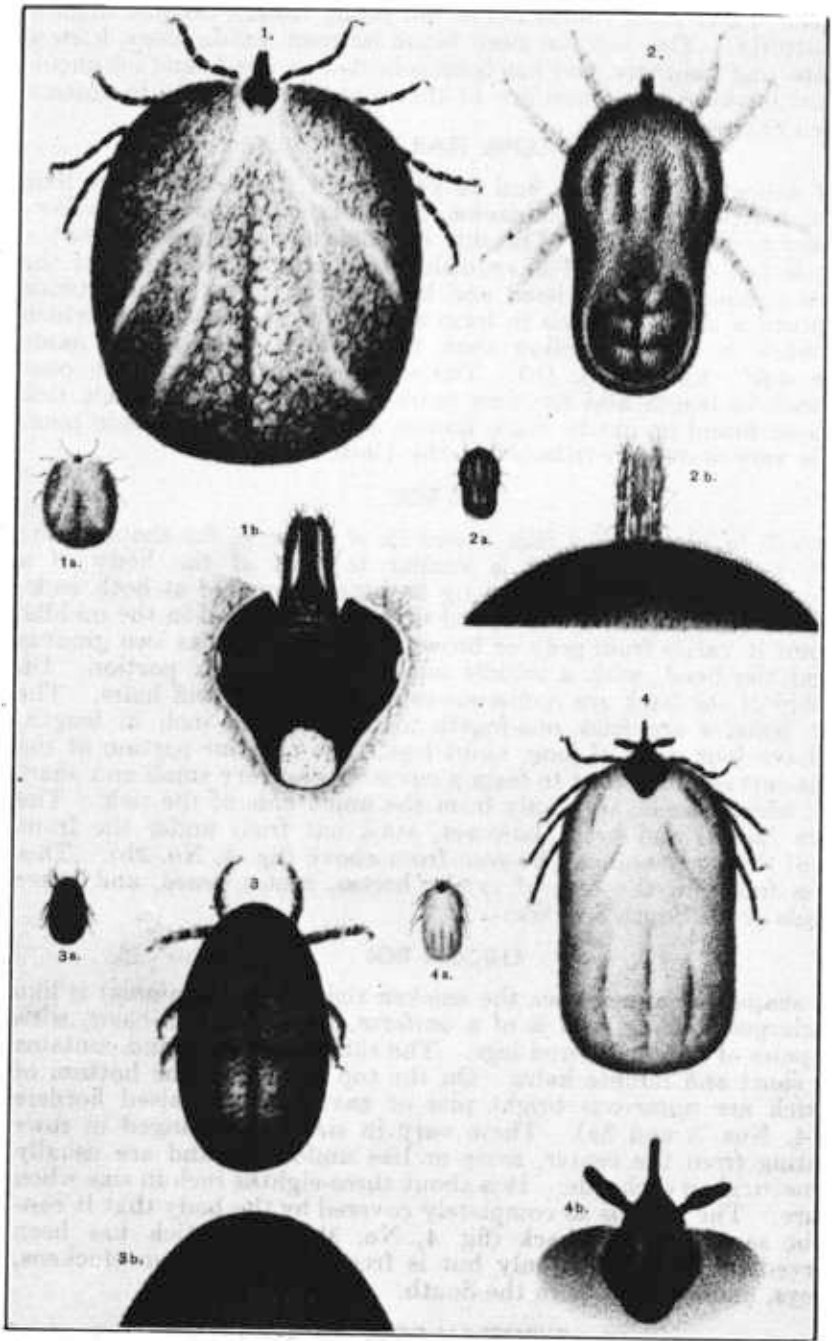

FIGURE 4.—Various ticks that infest cattle. 1. Mature female lone star tick, enlarged; 1*a*, same, natural size; 1*b*, head and shield of same, magnified 15 times. 2. Mature female ear tick, enlarged; 2*a*, same, natural size; 2*b*, head of same protruding from beneath, magnified 15 times. 3. Mature female chicken tick, enlarged; 3*a*, same, natural size; 3*b*, upper portion of same, head invisible, magnified 10 times. 4. Mature female European dog tick, enlarged; 4*a*, same, natural size; 4*b*, head and shield of same, magnified 15 times

terior portion of the body. The four pairs of legs are longer, thicker, and stronger than those of the cattle tick. The head and shield are brown red in color and similar in shape to those of the castor-bean tick but less oval and rather more lozenge shaped, with more acute lateral angles and narrower posterior angle (fig. 4, No. 4b). The palpi, or feelers, are longer and more prominent than in the cattle tick but not so long as in the castor-bean tick. This tick has been collected from dogs, cattle, sheep, foxes, rabbits, squirrels, gophers, cats, birds, man, and other hosts in eastern United States.

SOME APPARENT EXCEPTIONS TO THE TICK AS A CARRIER OF TICK FEVER

TICK FEVER IN ANIMALS APPARENTLY NOT INFESTED WITH TICKS

One objection that has been advanced against the fact that the cattle tick is a carrier of tick fever is that cattle sometimes are found to be suffering with the disease without showing the presence of ticks on their bodies. This condition, in the case of southern cattle, may be explained on the hypothesis that the animal already had its blood infected with the microparasites and under normal conditions was immune from tick fever; however, as a result of lowered vitality caused by some other diseases, or by exposure, privation, injury, rough handling, etc., this immunity has become reduced and finally overcome, and the parasite of tick fever, dealing now with an impoverished condition of the animal, succeeds in producing tick fever. Since the experiments of the Bureau of Animal Industry show that the blood of an immune animal may contain this microparasite for at least 13 years after removal from all sources of infection, it would appear that this recurrence of disease in immune animals placed under adverse conditions could occur at almost any period of their lives, and may be termed a relapse. Thus it has been frequently noted that southern cattle, born and raised in infected pastures but later freed of ticks and placed on noninfected soil, have died of tick fever when their health was so weakened as to permit the parasites already infecting the blood to overcome the natural resistance of the body and produce the disease.

Again, in certain dipping experiments where the animals had been roughly handled and unduly exposed after having been dipped in a severely irritating solution, a few deaths occurred from tick fever among cattle which were known previously to have been immune—tick-infested southern animals—but whose vitality had been reduced through these extraordinary conditions.

On the other hand, when this disease is observed in northern animals, the young seed ticks may be so small and so few in number as to be passed readily by even a careful examination, yet numerous enough to cause the infection. In such cases the proof will be found either by prolonged search or in the fact that other animals subsequently take the disease with larger ticks apparent on the skin.

SOUTHERN CATTLE INFESTED WITH FEVER TICKS MAY DIE OF TICK FEVER

When cattle born and raised in the South die of tick fever, it is proof that they never came in contact with infected cattle ticks before, or that they were raised on tick-free pastures, or that they

belong to those cases of immune southern cattle which lose their immunity when subjected to adverse or extraordinary conditions, such as those mentioned above. Otherwise they would have been unsusceptible and would not have developed tick fever. Southern cattle when raised and kept in districts free from cattle ticks, fail to secure the natural immunity induced by gradual and constant tick infestation from birth, and they are just as susceptible to the disease as are northern animals. Under certain conditions, as when living on horses, mules, etc., fever ticks lose their infectiousness, and when southern cattle not previously infected with any but these noninfected ticks come in contact with infected ticks they are just as susceptible as cattle raised on tick-free pastures, as indicated below.

HARMLESS TICKS MISTAKEN FOR FEVER TICKS

A very prolific cause for argument against the relation of ticks to tick fever has been the confusion which exists with reference to the various species of ticks observed on cattle. Some stockmen have claimed that ticks will not cause tick fever, because their experience has not been with the cattle ticks, but with the species of ticks described in the preceding pages, which are harmless so far as their ability to transmit tick fever is concerned, or with the noninfected cattle tick mentioned below. A similar experience with these harmless ticks on woodland far removed from cattle and the false assumption that they were cattle ticks have led others to claim that it would be impossible to eradicate the latter from infested pastures. However, their life histories are not parallel, since the cattle ticks demand the blood of cattle or equines in order to mature, while the ear, dog, lone star, and other ticks do not. Thus, if the fever ticks can be separated from these animals for a definite period they will die from lack of a host.

SUSCEPTIBLE ANIMALS HAVING FEVER TICKS WITHOUT TICK FEVER

In rare cases it has been observed that certain cattle ticks do not contain the Protozoa of tick fever, and when such ticks fail to produce disease in susceptible animals some persons have been led to argue that none of this species will transmit the infection. Cattle ticks without the virus of tick fever in their bodies are termed noninfected ticks. They may have lost their infectious property by living on a nonsusceptible animal, such as a horse, mule, ass, or suckling calf, as experiments have shown that a generation of infected ticks on these animals will eliminate the infection from their bodies, and when the next generation of seed ticks is placed on susceptible cattle no disease is produced. These ticks will become reinfected, however, if allowed to infest southern cattle containing the tick-fever Protozoa in their blood. Noninfected fever ticks are so very uncommon that it is necessary to treat all fever ticks as infected and capable of transmitting tick fever.

FEVER TICKS ON OTHER ANIMALS WITHOUT PRODUCING DISEASE

The reason that fever ticks can remain on animals other than cattle without producing the disease is that these animals are not susceptible to tick fever. Numerous experiments have shown that only bovines contract tick fever, so it is not difficult to understand why other hosts can be infested with impunity.

OTHER INJURIOUS EFFECTS OF CATTLE TICKS

Many cattle owners who have always been accustomed to see both ticks and ticky cattle on their farms are unfortunately not inclined to attach much importance to cattle ticks, and as a rule, through lack of appreciation of their damaging effects, placidly consider them as of little consequence. That ticks may be detrimental to their hosts in several ways has probably not suggested itself to these stockmen, and it therefore seems necessary to emphasize the fact that, in addition to their relation to tick fever, they may also be injurious to cattle as external parasites. While the power of transmitting tick fever is undoubtedly the most dangerous property possessed by the cattle tick and is the principal cause for adopting stringent measures in securing its complete eradication, nevertheless there still remain other good reasons for the accomplishment of this achievement. True, a few parasites may remain on cattle indefinitely without causing any noticeable effect, but it is not uncommon to notice bovine animals on pastures with their hides very heavily infested with these pests. In such cases it can readily be seen that the continuous sucking of blood causes more or less impoverishment of the circulation. The cattle must therefore be fed more heavily in order to meet the demands of the parasites in addition to the ordinary needs of the animals. This condition, together with the loss of blood, frequently induces an irritable state and evidences of uneasiness commonly known as "tick worry," which results in the loss of energy and in other derangements of the animals' health. It may in some cases become so pronounced, especially in hot weather, that the animal will lose flesh in spite of good pasturing, thereby reducing the vitality and rendering it more susceptible to the inroads of disease. Moreover, if the infestation of ticks is not controlled, the cattle may be so reduced in condition that growth is retarded, and in the case of young animals, they may never become fully developed but remain thin, weak, and stunted—a condition that has been termed "tick poverty"—and easily succumb to other diseases as a result of lowered vitality.

In milk cows this debilitating influence of the numerous ticks is shown in a greatly reduced milk supply. This should not appear strange when it is considered that some animals harbor many thousands of these bloodsucking parasites. If these parasites are crushed it will be found that their intestines are completely filled with a dark, thick mass of blood abstracted from the animal host and containing nutriment that should go to the formation of milk and flesh and the laying on of fat. In some rare cases the large number of bites over a limited area of skin may be followed by infection with pus-producing organisms, giving rise to small abscesses which may terminate in ulcers. The discharge from such sores, or in some cases the mere oozing of blood serum through the incision made by the mouth parts of the ticks, keeps the hair moist and matted together, and the laying and hatching of fly eggs in these areas give rise to infestation with destructive maggots, causing ulcers and other complications that require medical treatment.

These statements regarding the secondary injurious effects of cattle ticks also apply to those ticks which have been previously spoken of as harmless so far as tick fever is concerned, and in fact to all external parasites. Therefore, it is just as important to eradicate the cattle

ticks for reasons other than those associated with tick fever as it is to exterminate lice, fleas, and other vermin. Furthermore, cattle ticks, aside from the losses sustained by their purely parasitic effects, are the greatest menace to the profitable raising and feeding of cattle in the South, because they are an obstacle to cattle traffic between the infected and noninfected districts.

LOSS OCCASIONED BY CATTLE TICKS

The economic aspect of the tick problem is unquestionably of the greatest practical interest, since the fundamental importance of all the other questions which surround it depends on the actual money value involved. A careful and conservative estimate made in 1906 placed the annual loss caused by the ticks in the United States at $40,000,000 and indicated that the ticks also lowered the assets of the South by an additional $33,000,000. Present losses are materially less, however, as the quarantined area has been greatly reduced each year as tick eradication extends into new areas. The principal items of loss in the regions formerly infested with ticks are set forth below.

Since May 1, 1928, the interstate shipment of tick-infested cattle for any purpose has been prohibited, making necessary the trouble and expense of dipping and freeing cattle for shipment. Formerly animals coming from an infected district and sold in the southern pens at northern markets brought from one-half to 1½ cents a pound less than the quoted market prices. The handicap that was thus placed on cattle raisers as a result of this decreased value of the stock averaged at this figure from $3 to $9 a head, allowing an individual weight of 600 pounds for all classes of animals. This decreased value reacted and fixed the valuation of all cattle in the infected territory, thereby reducing the assets of the cattle industry of that section. In addition there is a very heavy loss from the decrease in flesh and lack of development of southern cattle occasioned by the parasitic life of the ticks from without and by the blood-destroying and enervating properties of the protozoan parasites within.

The presence of the tick among cattle not only lessens the value of the cattle on the hoof but causes the gradings of the hides that have been infested with ticks as No. 4 quality. The same hide, if free from tick marks, would grade No. 2. The difference in price between these two grades of hides is from 3 to 5 cents a pound. As the hide of a steer weighs about 42 pounds, the presence of the tick causes a loss in the hide alone of from $1.25 to $2.10 a hide. The increase in the value of the hide alone would more than pay the cost of tick eradication.

The shrinkage in milk production of cattle harboring many ticks will average 1 quart a day, which in the aggregate is a heavy loss. The damage resulting to the southern purchaser of northern purebred or high-grade cattle has been another item of no small moment. About 10 percent of such cattle taken into tick-infested areas die of tick fever even after they are immunized by blood inoculations, and about 60 percent of them succumb to tick fever when not so treated. As they are usually expensive animals and of a highly valuable strain of blood the loss in certain cases is excessive and in others almost irreparable, owing to the possible extinction of some particular type especially selected for the improvement of the herd.

Another instance in which it is difficult to figure the injury done by the ticks is in the case of death of nonimmune cattle in the tick-free pastures in an infested area. Such animals are as susceptible as nonimmune northern cattle, and as there are tick-free pastures in the quarantined areas losses following exposure to ticks are possible. These losses can scarcely be computed, as the death rate depends so much on the season of the year when exposure occurs and on the age of the animal affected. However, the deaths among such cattle are considerable, although this fact is little appreciated or understood by many outside the infected area.

On rare occasions a small outbreak of tick fever has occurred north of the quarantine line as a result of improperly disinfected cars, of unscrupulous dealers who break quarantine regulations, or of some accidental condition. Such damage, however, was slight, but should be considered in summing up the loss occasioned by the fever tick. A heavy expense was also incurred by the Government and the States in enforcing the regulations that apply to the quarantine area. Another loss which was indirectly sustained by the southern-cattle industry through increased freight rates was the cost, to the railroad companies, of cleaning and disinfecting the cars that carry ticky cattle.

These statements are sufficient to indicate that the loss to the quarantined section from the cattle tick has been enormous. Such a series of encumbrances as those recorded could be carried by the cattle industry of no other section of the country than the South, whose excellent pastures, rich soil, and salubrious climate were the only reasons for its ability to overcome such obstacles in meeting the competition of the West. And it is the inherent capacity of the South for greatly increasing its herds and enlarging its pasture lands that made the actual loss even secondary to the potential loss from restrictions necessitated by the presence of the cattle tick.

PERIOD OF DEVELOPMENT OF DISEASE AFTER EXPOSURE TO TICKS

The length of time elapsing between the exposure of susceptible cattle to the cattle tick and the appearance of tick fever among them is dependent on the climate and the development of the ticks. Thus, if any northern animals are placed on pastures or highways, or in pens, cars, etc., in summer immediately after the premises have been infested with the ticks from southern cattle, tick fever may occur in from 30 to 60 days, as the females that drop from the southern cattle must lay eggs and these must hatch before the northern animal becomes infested with ticks and thereby inoculated with the disease. In cool weather this period may extend to 90 days, as it takes much longer for the eggs to hatch. Where northern animals are not exposed in an infested pasture until the ticks which fell from the southern cattle have laid eggs and the larvae, or seed ticks, are already present, the northern cattle will develop symptoms in 13 to 15 days in hot weather. Thus under natural conditions the disease appears in 13 to 90 days after exposure. After the seed ticks become attached to the animal the disease will appear in about 10 days in summer, and after a somewhat longer period in cooler weather. In fact, the disease may occur before the ticks are large enough to be seen without a very careful search. By artificially inoculating a cow under the

skin or into a vein with virulent blood the disease may be produced in 3 to 10 days.

SYMPTOMS

The symptoms of tick fever present two distinct types, the acute and the chronic, depending on the time of year the disease makes its appearance and the susceptibility of the animals attacked.

ACUTE TYPE

In the acute form of the disease the temperature rises within 24 to 48 hours to 107° or 108° F., and the animal rapidly shows signs of being affected with a severe malady. It is depressed, leaves the herd, and lies down or stands off by itself with head lowered, ears dropped, feet drawn together, and back arched from the pain in the liver and kidneys. The muzzle is dry, the appetite lost, and rumination ceases. Constipation is always present during the first stages of the disease, but it frequently gives place later to diarrhea, and the manure is usually heavily stained with bile and in rare cases may be mixed with blood. The number of respirations may rise to from 50 to 90, while the pulse beat varies from 90 to 120 per minute.

The changes which occur in both the urine and blood are extremely important, but the urine will receive first consideration here, as it is more readily examined by the layman than the blood. The peculiarity of the urinary secretion is that it is bloodstained, from which symptoms the disease has derived its name of "red water." The Protozoa in the circulation break up the red corpuscles, liberating the hemoglobin, which is the coloring matter of the blood. This discoloration of the urine is present in the majority of the acute cases, but it is frequently wanting in the chronic form of the disease. The color varies from a mere pinkish tint to an almost black color, depending on the rapidity of destruction of the red cells and the excretion of the coloring matter through the kidneys into the urine.

The blood also furnishes great assistance in making a diagnosis of suspected tick fever, and the finding of the intracellular parasite microscopically is conclusive evidence. The blood, as it oozes from a small incision in the skin, is pale and watery, indicative of great reduction in the cellular element, and is readily seen to differ markedly from the normal red blood of healthy animals. Sometimes there is such a lack of blood in the vessels of the skin that a very deep incision has to be made in order to obtain sufficient blood for inspection. It is also at times noted that the power of the blood to coagulate is so reduced that when it once starts to flow it is only after a considerable time—or by applying pressure—that the hemorrhage is stopped. In the majority of cases, however, the tendency of the blood to clot is unaffected.

Cerebral symptoms are noticed in a certain percentage of cases, manifesting themselves in the form of staggering gait, disturbances of vision, or delirium. There is in milk cows a reduction or a complete stopping of the milk secretion. Abortion is also very common in pregnant animals. Death usually occurs within three or four days, and is generally preceded by a marked fall of body temperature to normal or even subnormal a few hours before the fatal termination. In nonfatal cases the temperature falls gradually after the crisis and soon reaches the normal, but recovery is prolonged over weeks and

even months, as a great deal of time is required to regenerate the greatly impoverished blood.

CHRONIC TYPE

The chronic form of the disease appears under natural conditions usually in the late autumn and early winter. It can be produced experimentally, however, by placing a few ticks on the skin of a susceptible animal—a fact of very great importance in the production of immunity against the acute type among northern cattle.

This form shows all the symptoms of the acute type, but in a milder degree. The temperature usually remains about 103° and never exceeds 105° F. There is loss of appetite, stoppage of rumination, constipation, and albumin in the urine. An anemic condition of the blood, as indicated by the pale and bloodless mucous membranes, is also present, but hemoglobin is not usually excreted by the urine; hence the red-water symptom is absent. There is also excessive loss of flesh and before the end of the attack, the affected animal is greatly emaciated. Although death rarely occurs, the valuation of the animal is much reduced.

RELAPSES

Following recovery from an acute attack, when the red blood cells have apparently reached their normal number, there has frequently been observed a relapse or recurrence of the disease in the mild, chronic form, accompanying which there is a second period of destruction of the red cells. This follows within three to six weeks after the symptoms of the acute attack have subsided. For a considerable time it was unknown whether this was a relapse of the acute attack or due to reinfection from a second generation of ticks. Smith and Kilborne, however, proved that it could occur as a relapse without the presence of ticks, but that it may also in some cases be caused by a second extraneous infection. In some cases the apparent relapse is probably the occurrence of anaplasmosis following a simultaneous infection with this disease and tick fever. The fever and other symptoms of anaplasmosis occur after the acute symptoms of tick fever have subsided.

APPEARANCE AFTER DEATH

The post mortem examination should be made as soon as possible after death, as the carcass of an animal dead of tick fever undergoes decomposition very rapidly. The skin should always be first examined for the presence of the cattle tick, as the discovery of any of the forms of this parasite on the skin of the escutcheon, thigh, or belly leads at once to a suspicion of the presence of the disease. The skin is usually normal in appearance, no visible alterations being present except possibly the small swellings, minute hemorrhages, and perforations from the bites of the ticks. Upon cutting into the hide and skinning the carcass a marked lack of blood in the blood vessels of the skin and underlying tissues is observed. Occasionally there may be noted a yellowish, jaundiced discoloration of these tissues. This is due to the alteration of the bile-secreting function of the liver, but is by no means present in all cases, being most constant in the acute, rapidly fatal form of the disease.

Probably the most marked pathological alterations in the disease are found in the liver. This organ is very much enlarged and has a yellowish, mahogany-brown color, due to the bile it contains. This secretion becomes excessive and minute plugs of congealed bile form in the small bile ducts, thus stopping them and damming the bile in the organ, which produces the yellowish color. This does not occur evenly throughout the organ, and consequently it has a mottled appearance. The gall bladder is usually distended with bile and its mucous membrane often contains numerous minute hemorrhages or bloodshot spots. The bile is very thick, has the appearance of "chewed grass," and contains numerous firm, irregular flakes. The spleen also shows marked changes. Normally this organ weighs from 1½ to 2½ pounds, but in cases of tick fever it is enormously enlarged, sometimes reaching four times its normal dimensions. It is very dark at times, due to the enormous accumulation of red cells and hemoglobin within its substance. On cutting into it the pulpy tissues will sometimes run out as a semifluid, blackish mass, due to the breaking down of its structures.

In death from the acute type of the disease the kidneys are usually found to be very dark in color and congested. The blood vessels are engorged with blood and there is watery infiltration of the surrounding fatty tissue. In the older, more chronic cases the kidneys are paler and somewhat flabby.

The bladder usually contains a varying quantity of urine, which may or may not be bloodstained. The mucous membrane frequently contains a few minute hemorrhages.

No characteristic lesions are found in the stomach, intestines, heart, or the lungs.

COURSE AND TERMINATION OF THE DISEASE

The course of the disease depends not only on the time of the year the infection occurs, but also on the age, strength, and susceptibility of the animals attacked. When mature, susceptible cattle contract the disease in the hot summer months, death usually occurs within a week—generally 3 or 4 days—after the first appearance of symptoms, but it may follow inside of 24 hours.

In the infections of partially immune southern cattle and when nonimmune cattle are infected in the late fall, however, the course of the disease is much more prolonged and covers a period of many weeks or even several months. In this type the continuous fever causes exhaustion, while at the same time the enormous destruction of red blood cells interferes very materially with the nutrition of the patient. As a natural consequence emaciation becomes marked, and this, together with the poor appetite, leads to a fatal result in some cases. In the majority of cases, however, in spite of the severe alterations of the blood and internal organs, the animals begin after several weeks to show improvement. The temperature becomes normal and there is a tendency toward regeneration. This, however, requires weeks and months, the animals in the meantime appearing weak and thin, having pale mucous membranes. During the recuperative period the animal should by no means be fed excessively, as numerous cases of fatal gastrointestinal disturbances have been

reported from overfeeding. The few animals which recover from the acute type of summer are quite likely to have a relapse in the form of the chronic type in the fall.

The mortality in adult susceptible cattle, as the statements above readily show, may vary considerably, and ranges from 90 percent in the months of July and August to less than 50 percent in the late autumn and early winter. The prognosis must therefore depend on the time of year the outbreak occurs. In animals under 9 months of age the course of the disease is usually short and the affection seldom fatal, while the death rate among 1-year-old cattle during the hot season is about 25 percent and less than 10 percent in the fall and winter. Between 1½ and 2 years of age the mortality is about double that at 1 year.

INFECTIVE CHARACTER

Tick fever belongs to the group of infectious diseases, and it is a typical example of the few diseases of this class which do not have the property of being contagious. It is infectious because it is due to the entrance and multiplication of a pathogenic microorganism within the body, but sick animals, in the absence of ticks, can remain in intimate association with healthy, susceptible animals indefinitely without transmitting the disease to them, and hence it is not contagious. Furthermore, a cow perfectly healthy in appearance may contain in its blood the tick-fever protozoan, which, when transmitted to susceptible cattle by the fever tick, will produce the disease. It is certain that the organisms are present in varying numbers in the manure and urine of infected animals, and yet susceptible animals have never been known to become affected from grazing over tick-free pastures soiled with excrement from sick animals.

The experiment was made by the Bureau of Animal Industry of polluting a pasture with the blood and spleen of an animal dead of tick fever and then allowing susceptible cattle to graze in the field for 2 months, but the animals remained perfectly healthy. Moreover, the feeding of ground-up ticks and virulent blood failed to produce the disease, showing that the digestive tract is proof against the infection.

The disease therefore can be transmitted by three known methods only: (1) By the bite of the cattle tick; (2) by inoculating the blood of sick animals into healthy animals; (3) by inoculating the infected blood of apparently healthy southern cattle into nonimmune cattle.

ANIMALS AFFECTED

Numerous experiments have been made on various species of animals with highly virulent blood from cattle suffering with tick fever, but the disease has been produced in bovines only. Among those animals that have failed to develop the disease after inoculation may be mentioned horses, asses, sheep, pigs, dogs, cats, mice, rats, guinea pigs, rabbits, chickens, and pigeons. All bovine animals that have never been exposed to the disease are susceptible to tick fever, although sucking calves are so resistant as to be practically immune. Adult cattle are the most susceptible, and, if attacked

in the summer months, usually die, while in the fall and winter they more frequently recover. Calves under 8 months of age contract the infection in a very mild form, as a result of which they become immune to the disease.

PREVENTION

It is generally accepted that if southern cattle are entirely free from that species of tick known as *Boophilus annulatus* they may be allowed to mingle with the most susceptible animals without danger. Furthermore, it has been learned from the study of the life history of the cattle tick and from the fact that this tick infests pastures only transiently, never permanently, that its extermination is possible, and that the disease it causes may be prevented. Therefore, the various methods with these results in view should be directed toward the destruction of ticks on cattle and equines as well as their eradication from the pastures.

The details of these methods of eradication will not be discussed here, as this subject is fully treated in Farmers' Bulletin 1057, Cattle-Fever Ticks and Methods of Eradication, which may be obtained free upon application to the Department of Agriculture, Washington 25, D. C.

DISEASES MISTAKEN FOR TICK FEVER

The three diseases which may be confounded with tick fever are anthrax, blackleg, and anaplasmosis. The following are the main features of tick fever not found in anthrax: Young ticks are usually found on the hide of the affected animal; if occurring in the uninfected territory, the disease can invariably be traced to the shipment of southern cattle into the locality 30 to 90 days previously; young sucking calves as a rule are not affected; the mucous membranes become extremely pale and jaundiced, while in anthrax they are very red and congested; cattle only are attacked, while anthrax attacks all animals. On post mortem examination in tick fever the tissues under the skin are very pale, while in anthrax they are congested, with the blood vessels standing out prominently. The blood is thin, pale, and watery, whereas in anthrax it is tarry, black, and incoagulable. The bile is semisolid and contains numerous hard flakes, while in anthrax it is fluid. The spleen is affected somewhat similarly in both diseases, but the liver in tick fever is enlarged, yellowish, and mottled from the plugging of the bile ducts, whereas in anthrax the liver, although enlarged, is very dark in color and is congested.

Tick fever can usually be differentiated from blackleg by the fact that the great majority of victims of blackleg are between 6 months and 2 years of age. There is usually a total absence of ticks on the hide in the latter disease, while there are present superficial, crackling swellings which on being opened are found to contain gas bubbles with the peculiar odor characteristic of the disease. There is also an absence of bloodstained urine. On post mortem examination in blackleg the muscular tissues beneath the swollen areas are very dark and soft, with bloody fluid, while the liver, spleen, and kidneys are apparently unaffected.

Anaplasmosis, which in many respects resembles tick fever, has been recognized in a number of States, mostly Southern and Western States (Alabama, Arizona, Arkansas, California, Colorado, Delaware, Florida, Georgia, Idaho, Illinois, Iowa, Kansas, Louisiana, Maryland, Mississippi, Missouri, Montana, Nevada, New Mexico, North Carolina, Oklahoma, Oregon, Pennsylvania, South Carolina, Texas, Virginia, and Wyoming). As in tick fever, a microparasite in the red blood cells is the causative agent. In certain foreign countries several kinds of ticks, the blue tick (*Boophilus decoloratus*), the black tick (*Rhipicephalus simus*), the tropical cattle tick (*B. australis*), and the castor-bean tick (*Ixodes ricinus*) have been shown to be capable of transmitting the infection. Apparently the American cattle-fever tick and other American ticks are carriers of anaplasmosis. The common dog tick or wood tick (*Dermacentor variabilis*) and the brown dog tick (*Rhipicephalus sanguineus*) are capable of carrying anaplasmosis and other ticks probably will be convicted as carriers. Horseflies and certain species of mosquitoes can transmit the disease.

Anaplasmosis may be transmitted mechanically on hypodermic syringes, dehorning tools, and other instruments. The infection is usually acute and the mortality from 20 to 60 percent. The symptoms consist in suppression of the milk flow, loss of appetite, marked weakness, stiff gait with a tendency to lie down frequently, and often a high fever. There is usually a decided constipation, but at times a diarrhea. The urine is generally normal in appearance, not blood-tinged as in tick fever. The pulse is rather rapid, and likewise the breathing, which is accomplished with grunting sounds. The membranes of the mouth and eyes are pale and may have a markedly jaundiced appearance. There is always a considerable falling off in condition, the affected animal having a gaunt appearance. Death may occur in from a few days to a week or more after the animal gets down. Many cases recover, but it is usually several months before such animals regain their normal condition. On postmortem examination there is found a marked spotting of the heart, heart sac, and inner surface of the chest walls with small hemorrhages. The liver is usually enlarged and the gall bladder distended with thick bile. The spleen is greatly enlarged, softened, and dark colored. The white tissues of the body may have a yellowish cast. The blood is thin and watery and under the microscope shows the small dotlike microparasite, *Anaplasma marginale*, in the red blood cells.

IMMUNIZATION OF SUSCEPTIBLE CATTLE

BY BLOOD INOCULATION

Medicinal treatment of animals sick with tick fever was usually unsatisfactory. In the United States it is generally believed that this disease will be satisfactorily and finally disposed of only with the complete eradication of the cattle tick and all official work since 1906 has been with this end in view. However, it is sometimes desirable to export well-bred cattle to tick-infested countries or ship them to infested districts so they may be used to improve the quality of the native cattle already there. Before the discovery of the cause of tick fever it was found to be well-nigh impossible to introduce purebred cattle from the North into any of the infested regions

without suffering great loss—sometimes as high as 90 percent—within a few months after their arrival at the southern destination. It has now been found practicable to immunize this class of cattle so perfectly that the losses which follow their transportation to a tick-infested region are reduced to a minimum. Young animals 6 to 15 months old should, so far as possible, be selected for this purpose, as they are more readily immunized than adults, are more easily handled, and the dangers which may arise from pregnancy while undergoing the immunizing treatment are thus avoided.

Immunity in these cattle is obtained by introducing the microparasite of the blood into their systems. It may be done by direct artificial inoculation or by placing virulent young ticks upon the animals and allowing them to perform the inoculation in the natural manner. The subcutaneous injection of a small amount of defibrinated, virulent blood has been found, by means of prolonged experiment, the preferable method, as the number of microorganisms introduced can be more accurately gauged from the syringe than by allowing the infection to be produced by bites of ticks. Two or three inoculations, if repeated at proper intervals, are accomplished with greater safety to the animal than would be possible by means of a single inoculation. The amount first injected should be small and then gradually increased in the succeeding treatments.

The inoculation always results in a more or less serious attack of tick fever. Besides having a fever, there is a great diminution of red blood cells, and in about 3 percent of the cases a fatal termination; but the proportion of deaths resulting from the inoculation is small when compared with the fatalities among untreated animals taken into infested districts. To this number should be added those animals (less than 7 percent) that do not receive sufficient immunity by this method and succumb when exposed to infested pastures. Combining these failures it will be seen that by this method of immunization, instead of a loss of 90 percent among breeding stock taken South more than 90 percent can be saved. The animals should be carefully nursed through the attack and treated symptomatically. The intravenous injection of 100 to 200 cubic centimeters of a 1 percent solution of trypan blue will be found beneficial in these cases, as it serves to control the severe reaction and to reduce the loss from immunization.

Immunizing inoculations were formerly made by the veterinarians of some of the agricultural experiment stations of the Southern States without cost for the services rendered, a charge being made merely for the actual value of feed consumed by the animals and attendants' wages. These veterinarians also issued station bulletins which describe fully the necessary steps to be taken in securing the blood and injecting it into the animals to be immunized, so that the stock owner can follow the instructions with prospects of getting good results.

This operation is not a difficult one, and excellent results will follow where absolute cleanliness and ordinary care have been used, but undoubtedly the best results will be obtained by those who have thoroughly familiarized themselves with the nature of the disease and are experienced in extracting blood from animals. Two methods are in use and will be described separately. One consists in drawing the blood from the jugular vein of an immune animal and imme-

diately injecting it into the cattle to be immunized. It is comparatively simple, requires few instruments, and can be satisfactorily carried out where a small number of animals are to be immunized and if a suitable immune animal is close at hand. First, select an immune animal which is in good health and is infested with fever ticks or had them the preceding year. Fasten the animal securely, either by tying, throwing, or by placing in a chute. Clip the hair from a space about 4 inches in diameter over the jugular vein on the upper third of the neck, wash the skin thoroughly with a 5 percent solution of carbolic acid, and then fasten a strap or rope around the neck below the hairless area and draw it tight in order that the blood in the vein will be stopped, causing distention. With a large, hypodermic syringe needle, previously sterilized in a 5 percent carbolic acid solution, puncture the vein at a slight angle, directing the point forward. When the needle enters the vein the point can be rotated freely in contrast to the restricted movements if still in the tissues, and the blood will either drop or flow from the opening in the needle. Attach the disinfected syringe to the needle with piston in and gradually draw out the piston until the chamber of the syringe is full of blood, when the needle is withdrawn. From a yearling in fair condition a pint of blood may be taken without harm, while double this quantity may be taken from a 2-year-old, and four or five times as much from a 3-year-old or upward. The blood, before it has had time to clot, is immediately injected into the animals to be immunized, which have been previously tied or restrained, the hair clipped, and the skin disinfected at the seat of injection in the region of the shoulder. Inject then from 1 to 3 cubic centimeters, according to the age of the animal, under the skin of each animal until the blood is exhausted. When more animals are to be inoculated than one syringeful will inject, the operation may be repeated in the same manner. The only objection to this method is the possibility that the blood will clot in the syringe, but with practice and promptness this can be easily overcome.

The second method is better suited for the inoculation of a large number of cattle or where the immune animal is at a distance from the cattle to be immunized.

The preliminary steps—the clipping of the hair, disinfection of the skin, placing the rope around the neck to distend the jugular vein, and restraining the animal—are the same as for the first method. In puncturing the vein it is advisable to use a small trocar and cannula after sterilization in a 5 percent carbolic-acid solution, and, when the vein has been entered, to draw out the trocar, allowing the blood to flow through the cannula attached to a rubber tube into a perfectly clean and sterile vessel containing a 5-percent solution of citrate of potassium or sodium, to prevent the coagulation of the blood. The amount of citrate solution in the container should be one-twentieth of the quantity of blood which it is desired to collect. After sufficient blood has been drawn for the animals to be injected, a cork is placed in the top of the bottle, through which passes a long, rubber tubing. At the other end of this tubing is a needle, and in the middle is a T joint with a syringe at the stem of the T. By the use of valves at this joint the withdrawal of the syringe piston pulls the blood from the bottle, and the insertion of the piston with closure of the opposite valve ejects the blood from the needle. The citrated blood is inoculated under the disinfected

skin of the animals to be immunized as in the first method. This blood may be kept in a dark, cool place for one or more months without deteriorating and may be shipped to other points for use.

The place where this injection is made is immaterial, but for convenience a point just behind the shoulder is usually chosen. The dose and number of injections vary with the individual animals. When a large number of cattle are to be inoculated a special form of syringe devised by Pound, of Queensland, may be used (fig. 5). The syringe is so arranged by means of tubes and valves that by simply pulling out the piston of the syringe and pushing it in again the correct amount of blood is drawn up from the bottle and injected through the needle into the animal, thus obviating the necessity of continually filling the syringe and measuring out the dose. As a rule, it may be stated that 1 cubic centimeter should be injected into an old animal coming into the infested district, 2 cubic centimeters into a 2-year-old,

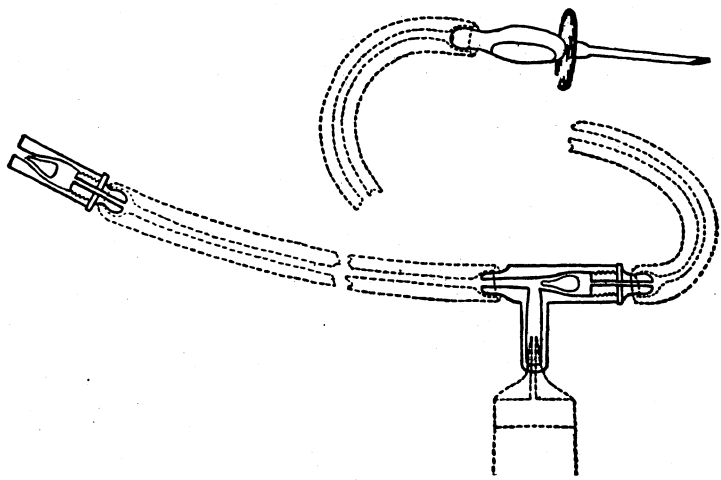

FIGURE 5.—Syringe for injecting blood

and 3 cubic centimeters into an animal 9 to 15 months old. It will be observed that, unlike the usual custom of applying treatment, the older animals take less than the young ones, owing to their greater susceptibility to the disease. Where an animal has reacted well to a first injection and shows a very high temperature, great reduction of red blood cells, or other symptoms indicative of reaction, it will not be necessary to repeat the injection; but in those cases where the reaction is slight a second injection should follow after an interval of 40 days, and, if need be, a third injection after a similar lapse of time, always increasing the size of dose 50 percent. A thermometer, to indicate the course and severity of the disease, is indispensable in this work. Usually after 3 to 10 days, sometimes longer, the inoculated animals show a mild type of tick fever, which runs a course of from 6 to 8 days and is followed in about 30 days after the injection with a second attack of a milder character than the first. After 40 days, when the animal has entirely recovered from the inoculation, a second injection may be given to increase its immunity. In some cases a

very severe type of fever follows the first inoculation, requiring careful nursing, symptomatic treatment, and the intravenous injection of 100 to 200 cubic centimeters of a 1 percent solution of trypan blue. A second, milder attack follows, usually in about 30 to 40 days, after which the animal need have no further inoculations. It is advisable to prevent any ticks from getting on the cattle until 60 days after their inoculation or until they have fully recovered, at which time a few ticks may be placed upon them in order to reenforce their immunity. Naturally, this time varies according to the type of the attack. As the best results with these immunizing experiments have been obtained in cool weather and with young cattle, it is recommended that animals from 6 to 15 months old be selected for inoculation, and that they be immunized during the late fall or winter months in order that they may enter tick-infested pastures in the spring without danger.

BY INFESTING WITH TICKS

Immunity may also be induced in susceptible animals by placing a limited number of fever ticks upon their bodies in order to produce the disease naturally. For this purpose only animals less than 1 year of age should be used, as the method is not applicable for older and more susceptible animals. On the bodies of these young cattle from 25 to 50 seed ticks should be placed, which in the course of about 10 days will occasion a rise of temperature and a mild form of tick fever. When the animal has entirely recovered from this attack, a second crop—double the number first used—should be applied to the animal in order to increase its power of resistance when pastured on infested soil. In order to carry out this method successfully a constant supply of seed ticks must be at hand. This can be accomplished by placing the mature females in a Mason fruit jar among some dirt and leaves and keeping them in a warm place. In a few weeks the eggs will have been laid and hatched, and a number of seed ticks will be present for use in infesting the cattle to be immunized. By placing a few adult females in the jar every two months there will always be a supply of these young ticks. This method of producing immunity by controlled tick infestation is not so safe as blood inoculation, since the quantity of germs injected can be more accurately regulated by means of a syringe.

FEDERAL SANITARY REGULATIONS

The sanitary regulations which have been made by the Department of Agriculture for the control of cattle shipments from the infected districts have for their initial purpose the prevention of the transportation of cattle ticks from infested regions to those that are not infested, whether on cattle or in stock cars or other conveyors. They are based on the fact that tick fever is carried only by the cattle tick; and the exclusion of this parasite from the noninfected territory has in every instance been found a certain method of excluding tick fever.

The regulations define the boundaries of the infected districts and prescribe the treatment required to render cattle tick-free and safe for movement from these infested areas. In consequence of the enforcement of these quarantine regulations tick fever has been prevented in the noninfected districts during recent years, and little or no hardship has been caused to the stockmen handling cattle from the infected

areas. Before the regulations were established the tick-infested district was rapidly extending northward, but since the quarantine line was established and rational regulations enforced in conjunction with the systematic tick-eradication campaign the quarantined area has been reduced to less than 1 percent of its original size. The complete elimination of this tick in infested areas is of the greatest importance to the cattle industry of the South—in fact, to the whole country—and it will continue to receive special consideration from this Department as well as from all of the interested States.

OTHER IMPORTANT MEASURES FOR REDUCING THE INFECTED AREA

The first and probably the most important step in eradicating the cattle tick is to start and continue a plan of educating the cattle owner as to the nature of tick fever and the method of its transmission. This may be best accomplished through farmers' institutes, motion pictures, the issuance of press bulletins and circulars, the publication of articles in agricultural journals, and, best of all, by personal intercourse between the agricultural population and stock inspectors who are capable of imparting the necessary information. There can be no doubt that the crying need of the infected country is not so much the development of new ideas for exterminating the cattle tick as it is to remove all doubts of stockmen regarding what they term the "tick theory," and to impress upon them the fundamental truths concerning the cattle tick, its relation to tick fever, and simple methods for its extermination. In some counties within the infected district the local authorities have organized cattle clubs composed of stockmen, with the view to interesting them in exterminating the ticks from their premises and in preventing cattle in adjoining tick-infested sections from coming upon their property. These organizations are the means of disseminating general information respecting tick-fever infestation and the cause of the restrictions placed on cattle in the infected district, and through them a concerted action of the cattle owners is obtained, resulting in the control and final eradication of the infection within a portion or the whole of a county. The success of such clubs is a constant reminder of what other organized stockmen could do.

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